IMPACT INDICATORS

RELEASE OF GERMPLASM FROM CIAT 1967-1998

AN INTERIM REPORT

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Introduction

Alleviating hunger and poverty through increased agricultural productivity has been at the heart of CIAT's mission since its foundation more than 30 years ago. The development and distribution of improved germplasm has been a central part of this effort. Improved germplasm of beans, cassava, rice and tropical forages from CIAT has reached farmers via national programs throughout the world.

During the past three decades, CIAT research has contributed to the development of 664 varieties that have been released by national agricultural research systems (NARS) in 51 countries worldwide in all continents (Figure 1). The availability of new germplasm has enabled farmers, depending on their circumstances and needs, to attain higher yields, suffer lower losses to pests and diseases, withstand soil and moisture constraints, and produce better quality crops.

Identification and release of improved germplasm is an essential first step in evaluating the impact of genetic resources research on agricultural productivity, alleviation of poverty and hunger, and a more sustainable use of natural resources. This paper summarizes current information on the release of improved genetic materials through CIAT. This information serves as an initial indicator of research performance and impact since it is through the release of new varieties to farmers that genetic research programs contribute to poverty reduction and increased agricultural productivity.

Since this paper gives only a partial and preliminary indication of impact achieved by CIAT research, it will be followed by future publications that will comprehensively document the extent of use of this germplasm and will attempt to assess its impact on agricultural production and human welfare. Moreover, improved germplasm is not the only output of CIAT's international research that impacts upon poverty, productivity and natural resources management. For example, CIAT has identified natural enemies of crop pests as well as beneficial micro-organisms that enhance crop performance. CIAT has developed improved research methods and decision support systems that contribute to enhanced management of natural resources. Scientific knowledge and training has contributed to national capacity to solve agricultural and natural resource management problems. Thus, documenting the release of improved germplasm from CIAT provides some indication of the impacts of CIAT research, but it does not give a comprehensive and complete picture of impact.

Broad Trends in Germplasm Releases

Ninety-eight percent of the germplasm coming from CIAT has been released by NARS in developing countries. Latin America and the Caribbean have been the biggest beneficiaries of releases of improved germplasm through CIAT (Table 1). Some 530 germplasm releases have occurred in this region, including all four CIAT mandated crops: beans, cassava, rice and tropical forages. In addition, Africa has benefited from a large number of germplasm releases in beans, while there have been numerous releases of improved cassava in Asia. In fact, Asian releases of CIAT cassava germplasm outnumber those for Latin America. Available data on rice germplasm releases are restricted to Latin America and the Caribbean (LAC), CIAT's mandated region. While the vast majority of CIAT releases have gone to LAC countries, there is no doubt that some CIAT germplasm has found its way into varieties in other regions such as Asia and Europe. Forage releases have so far been heavily concentrated in the LAC region.

Brazil is the country that has released the largest amount of material from CIAT, with 120 germplasm releases, covering all CIAT crops (Table 2). Colombia is second with 46 releases, while Mexico ranks third with 37 releases, followed by Cuba with 34 releases. All these countries have released germplasm from all four of CIAT's mandate crops, with rice being the most frequent release. Ecuador and Panama also have released CIAT derived materials for all four crops- beans, cassava, rice and tropical forages.

Rice from CIAT has been released in 23 countries in LAC, thereby attaining almost total coverage of the region. Improved beans have been released in 39 countries world wide, including 18 in Latin America and 14 in eastern and southern Africa. CIAT cassava has been released in 8 Latin America countries and 6 nations in Asia. Forages have been released in 14 countries, 12 of them in Latin America.

Over time there has been an increase both in the number and also in the diversity of materials released coming from CIAT (Table 3). The total number of releases of genetic materials coming from CIAT risen five fold, from 58 during the 1970s to 311 in the 1990s.

During the 1970s, almost all the germplasm releases were of rice, as CIAT built on the gains of the previous rice research done at IRRI by testing, distributing and adapting new materials for LAC production conditions. During the 1980s the rate of release of rice germplasm accelerated as materials with better adaptation to Latin American conditions were developed in collaboration between CIAT and NARS. By the late 1970s, bean varieties developed in CIAT's own program were also being released in substantial numbers. During the 1980s bean releases caught up to rice, and during the 1990s there were more than twice as many

bean releases as rice releases. In large part this is due to the fact that the greater diversity in bean production environments, systems, and market requirements demands more specialized varieties, each one of which covers a smaller area than would be the case for most rice releases. Because of this diversity it would take a larger number of bean releases to cover a given area than would be the case for rice.

By the 1990s practically all irrigated rice in LAC was covered in improved varieties. Nonetheless, taking into account that the data for the 1990s really only covers 7 complete years, the annual rate of release of new rice varieties with CIAT assistance appears as high in the 1990s as in the 1980s, even though the new varieties are often replacing previously released improved varieties. In contrast, in beans, the rate of releases of new varieties has continued to climb in the 1990s. In large part this is because many African countries have also begun to release improved bean varieties. Nonetheless, because of the relatively smaller areas covered in individual bean varieties, neither the total area in new bean varieties nor the percent of the area in improved varieties reaches the high levels attained in irrigated rice in LAC.

In the early 1980s releases began to emerge from CIAT's cassava and forages research, and these continued in the 1990s, with the number of cassava releases accelerating slightly in the 1990s. Initially the cassava releases were concentrated in Latin America, particularly in Colombia and Brazil. More recently, a growing number of cassava releases have been occurring in Asia, especially in Thailand, China, Indonesia and Vietnam.

NARS were particularly active in releasing forage germplasm in the 1980s, with Colombia and Brazil being the leading countries in this regard. Substantial areas are known to have been established with new forage germplasm in these countries. Because the diffusion of forages is much slower than in the case of annual crops, the adoption of some material originally released in the 1980s is still ongoing, lessening the pressure for further new releases of forages in these countries. More recently, forage germplasm releases have been increasing in Central America, especially in Costa Rica.

Table 3 also shows data on NARS releases of varieties which they developed without direct CIAT assistance or material input. CIAT may sometimes have played an indirect supporting role in developing these varieties, for example, through the development of breeding methods or the provision of technical assistance or training. Nonetheless, NARS breeders have had the full responsibility of developing these releases. Unfortunately, the available data may not be complete and thus may under-represent the level of NARS' breeding activity.

Nevertheless, it appears that NARS breeding of their own varieties has not significantly slackened nor been displaced by CIAT breeding. Table 3 shows, for

example, that the number of releases of improved varieties developed solely by NARS without direct CIAT involvement has been steadily rising since the 1970s for both rice and forages. Likewise, the development of improved bean varieties without direct CIAT help actually grew from the 1970s to the 1980s. Comparing the 1980s to the 1990s, the number of bean varieties being released by NARS on their own remains at about 7 releases per year.

Consequently, these data suggest that CIAT breeding has complemented a growing NARS production of new varieties, rather than crowding out NARS efforts on their own initiative. The combined efforts of NARS working on their own and working in collaboration with CIAT has made available to farmers a great and increasing diversity of new germplasm options.

Types of CIAT-Assisted Releases

The release of improved genetic materials from CIAT can come from four basic sources. The first is through exchange of native materials or landraces from collections maintained by CIAT. At an early stage in crop improvement significant gains can typically be made through the exchange of native materials from one region to another. In this paper, such releases are called "germplasm accessions", which essentially consist of landraces selected over generations by farmers.

Secondly, improved materials can be obtained through exchange in a genetic improvement network. In rice, such network exchange drew principally on prior work of IRRI, but also of national programs. In beans, network exchange has involved mainly the exchange of materials among NARS through networks that CIAT initiated.

Third, improved materials have emerged through CIAT's breeding programs. CIAT breeders develop advanced lines that are essentially finished products which can be utilized directly by NARS. CIAT also releases crosses, which are selected locally by national programs and then released as varieties.

Finally, national programs utilize as parents in their own breeding programs materials with desirable characteristics that have been developed by CIAT. In this case the NARS are producing the advanced lines while CIAT is providing an intermediate input in the form of parents.

The evolution of the types of materials released by CIAT is shown by decade for three crops in Table 4. Tropical forages are excluded because all the released materials fall into a single category, germplasm accessions. For the other three crops there is a remarkably consistent evolution in the types of materials released.

Initially the exchange of germplasm collection material is significant for both beans and cassava, but its importance declines strongly over time. This is because after the initial gains have been made from circulating existing materials, further gains can only be made through creating new variation through breeding. In the case of rice, this stage had already been fully exhausted by the time that CIAT began its rice research. Likewise, for rice and beans the circulation of materials from earlier international and national breeding work declines in importance over time.

Of increasing importance over time has been the development of advanced lines by CIAT. To a large extent this reflects the economies of scale of working with large germplasm collections to screen and recombine diversity for distribution to a broad set of users. The strategy of creating international public goods in Center breeding programs has clearly succeeded in providing to NARS an increasing amount of improved genetic material that they find useful to release to farmers. The demand for this type of output from CIAT appears to remain high.

Nonetheless, the growth in the use of CIAT developed parental materials foreshadows a further evolution in the Center-NARS partnership for genetic improvement. Increasingly CIAT is moving into a role of using advanced genetic techniques of biotechnology to identify and recombine useful genetic diversity. Once these materials have been developed, an growing number of NARS will be able to use them in their own breeding programs to produce their own advanced lines. Thus, over time it is expected that there will be a continuing trend towards greater use of CIAT parents as NARS take over a greater role in the production of advanced lines. Eventually it is expected that the production of advanced lines at CIAT will decline, and the use of CIAT derived parents will be the most important contribution of CIAT to NARS. Table 4 indicates that although still incipient, this process is now clearly under way in the cases of beans, cassava and rice.

Summary and Implications for Future Analysis

The data presented here demonstrate that with the direct assistance of CIAT, a great amount of new genetic material has been released to farmers by NARS. These releases have occurred throughout the world, but 98% in developing countries. Improved germplasm developed with CIAT assistance has been released for beans, cassava, rice and forages in a wide variety of countries. Overall, the volume of material developed with CIAT assistance is increasing while at the same time the amount of material produced by NARS without direct CIAT assistance is also increasing. The types of materials being released are changing over time. Initially there was a very significant role for direct utilization of collected germplasm, followed by subsequent importance of new lines developed by CIAT based on the germplasm collection. More recently, NARS are beginning to use CIAT materials as parents in their own breeding programs.

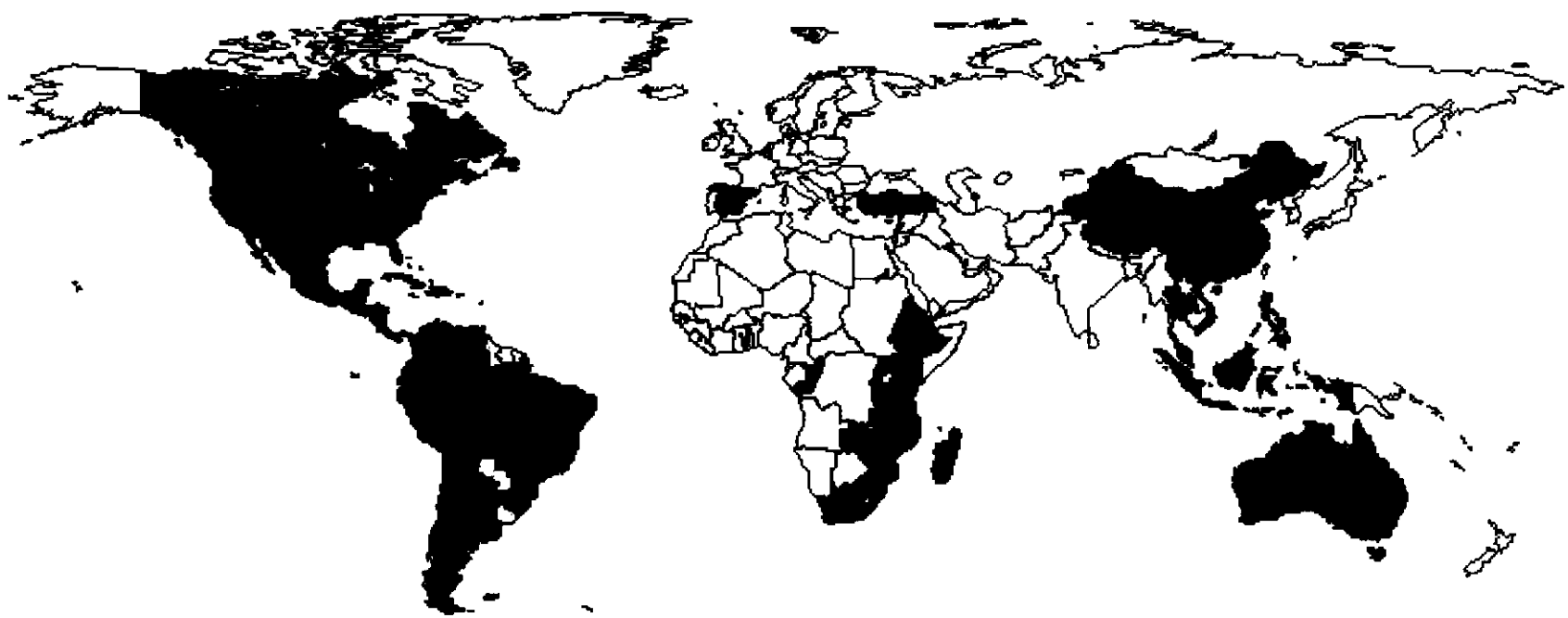
These data are indicative of the potential impact of new germplasm. However, to measure impact it is also necessary to know the extent of use of the new genetic materials by farmers and the effects that these material have had on productivity. In collaboration with NARS, CIAT has conducted over 80 studies of these issues. Abstracts of these studies have been published by CIAT, and are available on the world wide web at www.CIAT.CGIAR.ORG under Impact. These studies provide substantial documentation that the germplasm releases that have occurred,have led to adoption by farmers, changes in productivity, and improvements in welfare.

Currently CIAT is participating in a study sponsored by the CGIAR Impact Assessment and Evaluation Group that will marshall all available evidence to make a comprehensive estimate of the use and impact of improved genetic material developed with assistance from CGIAR centers. Results from this study will be forthcoming by the end of 1999. This study will not only better document the economic impact of CGIAR research to improve germplasm, but will also from the basis for addressing other important issues.

The economic value of varieties, and of their specific traits, needs to be elucidated. This information can help inform decisions about the economics of genetic resources conservation. At the same time, new legal regimes with respect to ownership rights to genetic resources have emerged out of the UNCED Rio convention on biodiversity as well as other policy decisions at the national level in many countries. Frameworks are needed to negotiate the use of these rights among different parties, including compensation mechanisms. Better genealogical data will make it possible to assess the economic contribution of the landraces and other varieties that make up today's improved varieties. This information will be critical to such negotiations.

Growing population, environmental degradation, and the risks of climate change all increase the pressure on agricultural research to respond rapidly with new, more productive genetic material for specific agroecosystems. The work of the CGIAR system in conservation, improvement and materials transfer is critical to meeting these challenge. Quantifying the value of these services will help insure that they will be available for future generations.

Figure1. Countries which have released CIAT Germplasm (including Rice, Beans, Cassava, Forages)



Rice
Beans
Cassava
More than one crop (Including Forages)

Table 1. Releases of Improved Germplasm with CIAT Assistance by Region, 1967-98.

	Beans	Cassava	Rice	Tropical Forages	Total
Latin American and Caribbean	225	22	240	43	530
Africa	93	0	0	0	93
Asia	1	25	0	1	27
Australia	2	0	0	1	3
Europe	7	0	1	0	8
North America	3	0	0	0	3
Total	**330**	**47**	**241**	**46**	**664**

Table 2. Varieties Released with CIAT Assistance by Crop, Country and Region, 1967-1998

REGION	COUNTRY	RICE	BEANS	FORAGES	CASSAVA	TOTAL
LATIN AMERICA AND THE CARIBBEAN	ARGENTINA	1	30			31
	BELIZE	1				1
	BOLIVIA	7	15			22
	BRAZIL	71	36	7	6	120
	CHILE	2	6			8
	COLOMBIA	21	11	7	7	46
	COSTA RICA	9	18	5		32
	CUBA	7	23	3	1	34
	DOMINICAN REP.	8	3		2	13
	ECUADOR	7	8	1	1	17
	EL SALVADOR	5	5			10
	FRENCH GUIANA	1				1
	GUATEMALA	10	11	1		22
	GUYANA	3				3
	HAITI		1		2	3
	HONDURAS	5	12	4		21
	MEXICO	27	4	4	2	37
	NICARAGUA	7	14	1		22
	PANAMA	9	8	3	1	21
	PARAGUAY	5				5
	PERU	19	12	2		33
	SURINAME	7				7
	URUGUAY	1				1
	VENEZUELA	7	8	5		20
AFRICA	BURUNDI		11			11
	CONGO		12			12
	ETHIOPIA		13			13
	KENYA		3			3
	MADAGASCAR		1			1
	MALAWI		7			7
	MOZAMBIQUE		4			4
	RWANDA		11			11
	SOUTH AFRICA		5			5
	SWAZILAND		3			3
	TANZANIA		7			7
	UGANDA		10			10
	ZAMBIA		3			3
	ZIMBABWE		3			3
ASIA	CHINA			1	4	5
	INDONESIA				3	3
	MALAYSIA				2	2
	PHILIPPINES		1		6	7
	THAILAND				7	7
	VIET NAM				3	3
AUSTRALIA	AUSTRALIA		2	1		3
NORTH AMERICA	CANADA		1			1
	USA		2			2
EUROPE	CYPRUS		1			1
	FRANCE	1				1
	SPAIN		3			3
	TURKEY		3			3
ALL COUNTRIES		241	331	45	47	664

Table 3. Number of Germplasm Releases by Decade, 1970-1998*

Crop	1970s		1980s		1990s**	
	CIAT	NARS	CIAT	NARS	CIAT	NARS
Rice	48	4	103	17	83	22
Beans	10	26	98	76	186	53
Forages	0	0	28	2	17	4
Cassava	0	0	22	na	25	na
Total	58	30	251	95	311	79

* Does not include data for releases prior to 1970 nor for releases for which a date could not be identified. NARS data is only for countries in which CIAT-assisted germplasm releases have occurred.

** Includes data through early 1998.

Table 4. Types of CIAT-assisted Genetic Releases by Crop and Decade (% of total releases)*

	Rice			Beans			Cassava	
	1970's	1980's	1990's	1970's	1980's	1990's	1980's	1990's
CIAT Germplasm Collection	0.0	0.0	0.0	30.0	18.4	11.3	54.5	8.0
CIAT Cross**	22.9	50.5	65.1	50.0	63.2	75.8	31.8	48.0
CIAT Parents	0.0	4.8	9.6	0.0	0.0	6.5	4.5	20.0
CIAT Network Exchange	77.1	44.7	25.3	20.0	18.4	6.5	0.0	0.0
CIAT Technical Assistance	0.0	0.0	0.0	0.0	0.0	0.0	9.1	24.0

* Includes data on varieties for which dates and categories are available.
** Includes both CIAT advanced lines and CIAT crosses selected locally.